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Ingredients for the Success of LED Lighting

Philip F. Keebler
Sr. Project Engineer

Transformations in Lighting
2012 DOE Solid-State Lighting R&D Workshop
January 31, 2012

Residential LED Lighting

Under-Cabinet LED Lighting

Kitchen Downlight LED Lighting

Recessed Downlight LED Lighting

Portable Desk LED Lighting

Outdoor LED Lighting

Shelf-Mounted Display & Task LED Lighting

Outside Wall-Mounted Porch Light LED Lighting

Outdoor Step LED Lighting

Outdoor Pathway LED Lighting

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Commercial LED Lighting












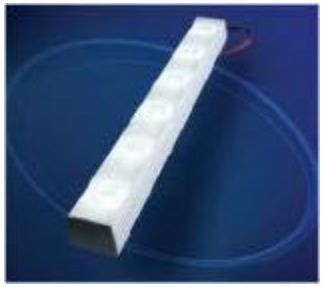


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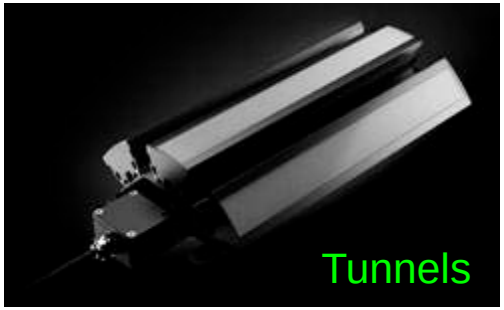
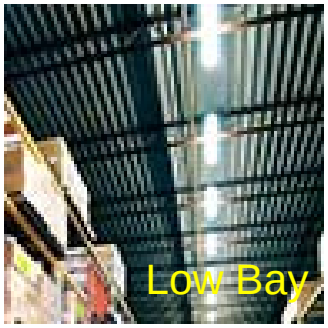
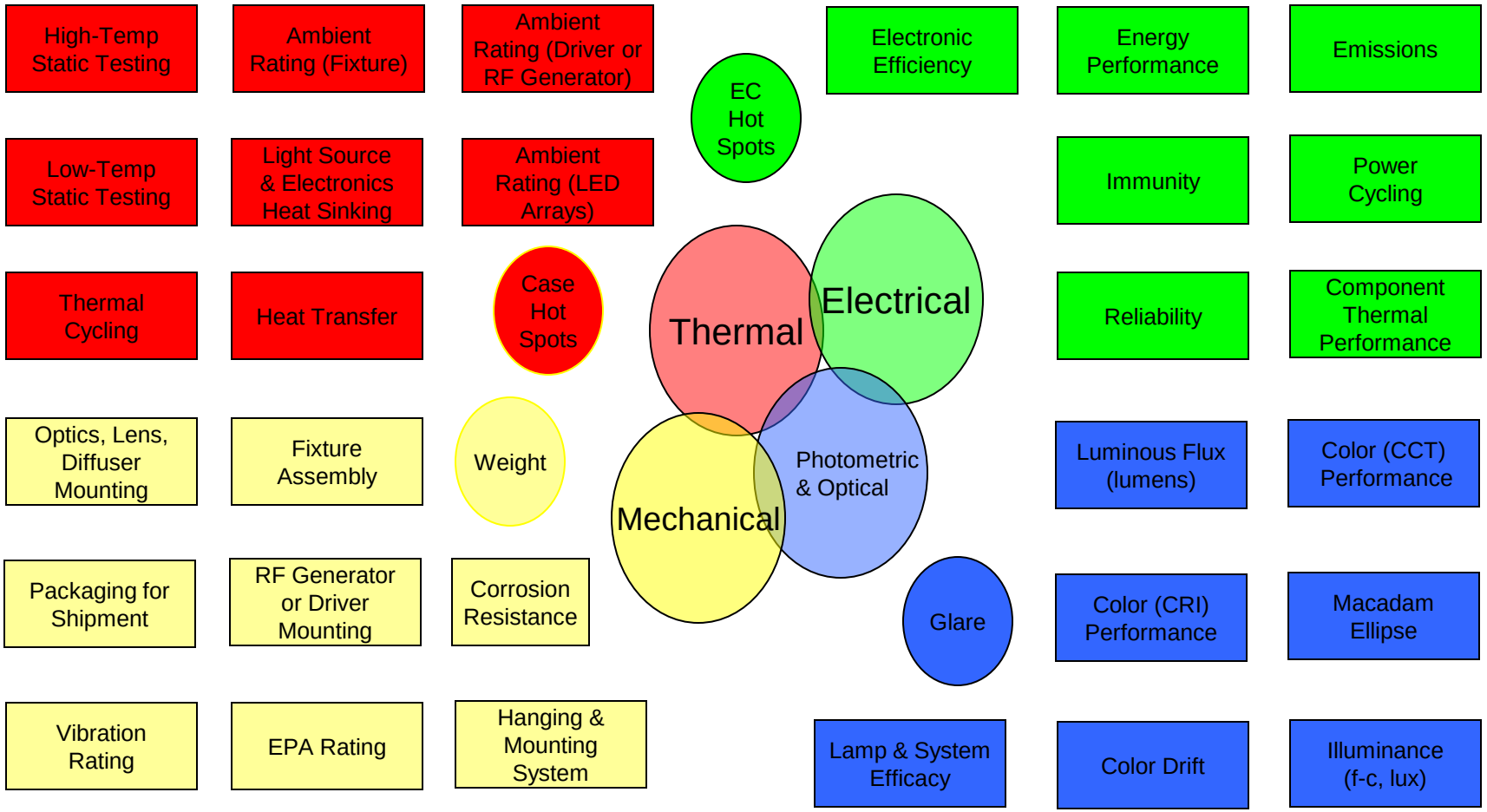
Industrial LED Lighting





What is Whole-Product Performance?

LED Lighting



Industry is Recognizing the Importance of Total Performance

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What we know…

- LED products will enter many markets
- Products with better designs and performance will improve the rate of consumer satisfaction
- Whole product performance is key
- Increased consumer satisfaction will foster development of more niches leading to increased product use
- Number of returned and failed products must decrease as more products are introduced
- All of the above affects economics of LED lighting
  - Consumer price
  - Energy cost
  - Manufacturing cost

What is Power Quality?

When things go "bump" in the night…then the lights flicker & power goes out…

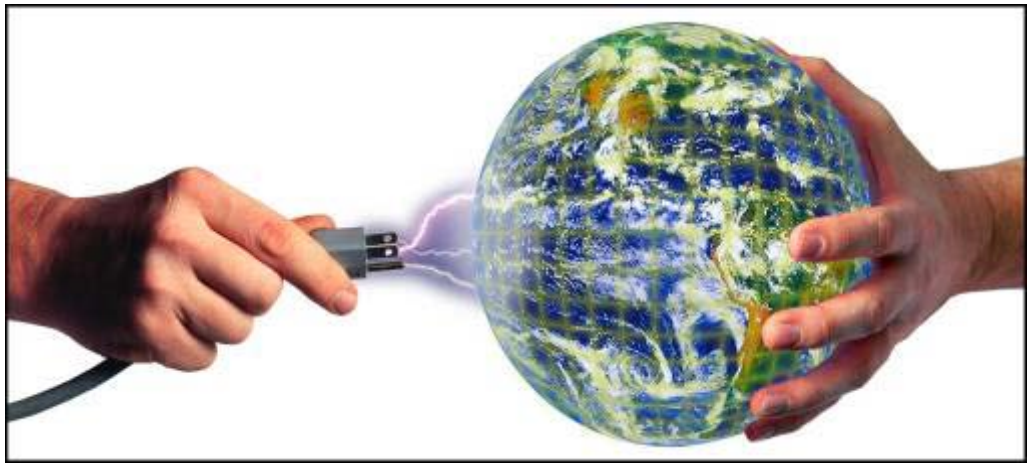
- Power quality is the concept of powering and grounding electronic equipment in a manner that is suitable to the operation of that equipment.

IEEE Standard 1100-2005 The Emerald Book

What is System Compatibility?

A Concept Developed by EPRI

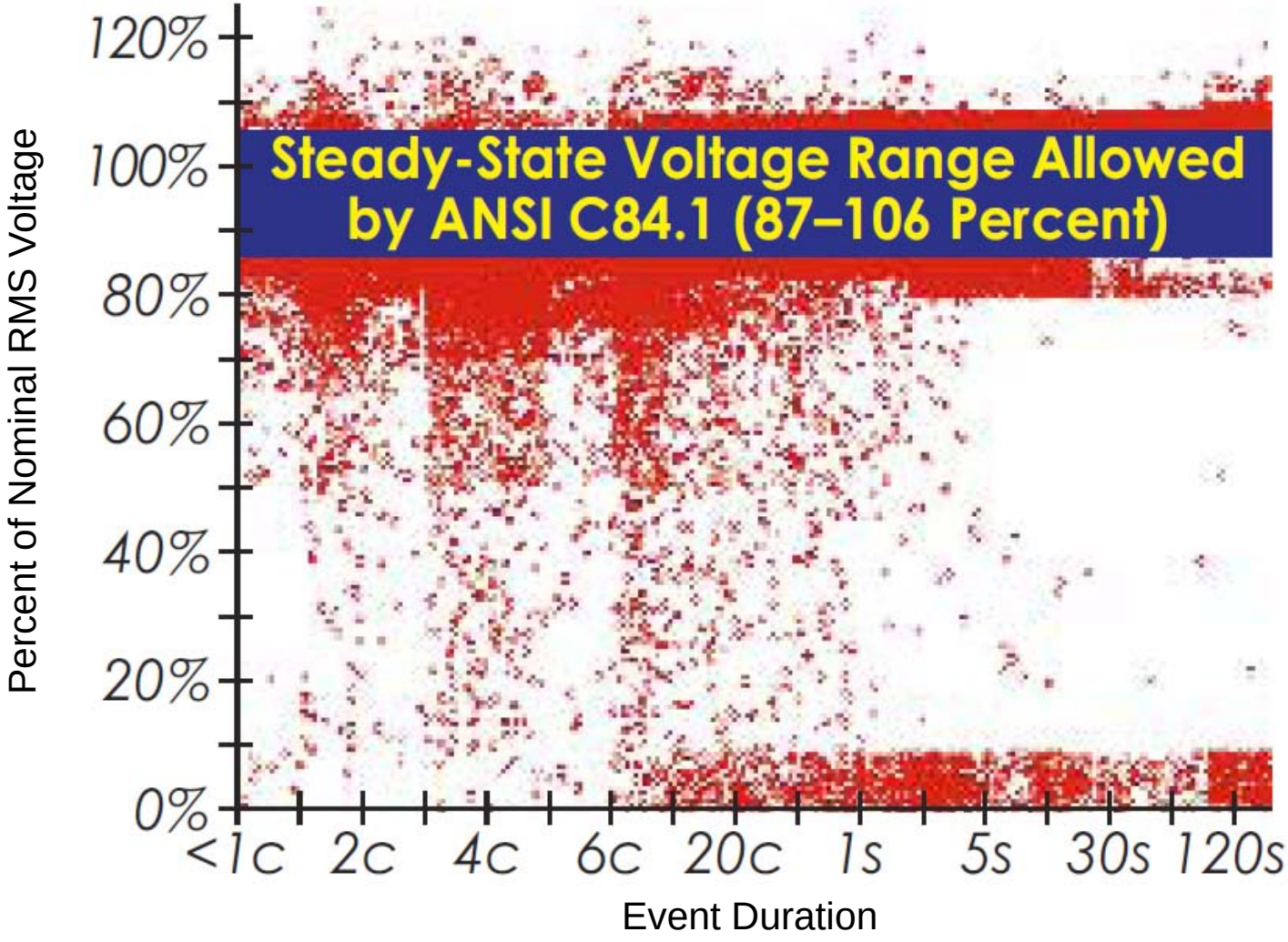
- System compatibility is the ability of a device, equipment or system, generally a load, to function satisfactorily with respect to its power-supply electrical environment without introducing intolerable electrical disturbances to anything in that environment.



Compatibility is critical to the sustainability of any electronic product!

The Electrical Environment is Complex

EPRI Research Results



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SC Test Program for LED Lighting Products

Part 1 – Energy Performance & Emissions

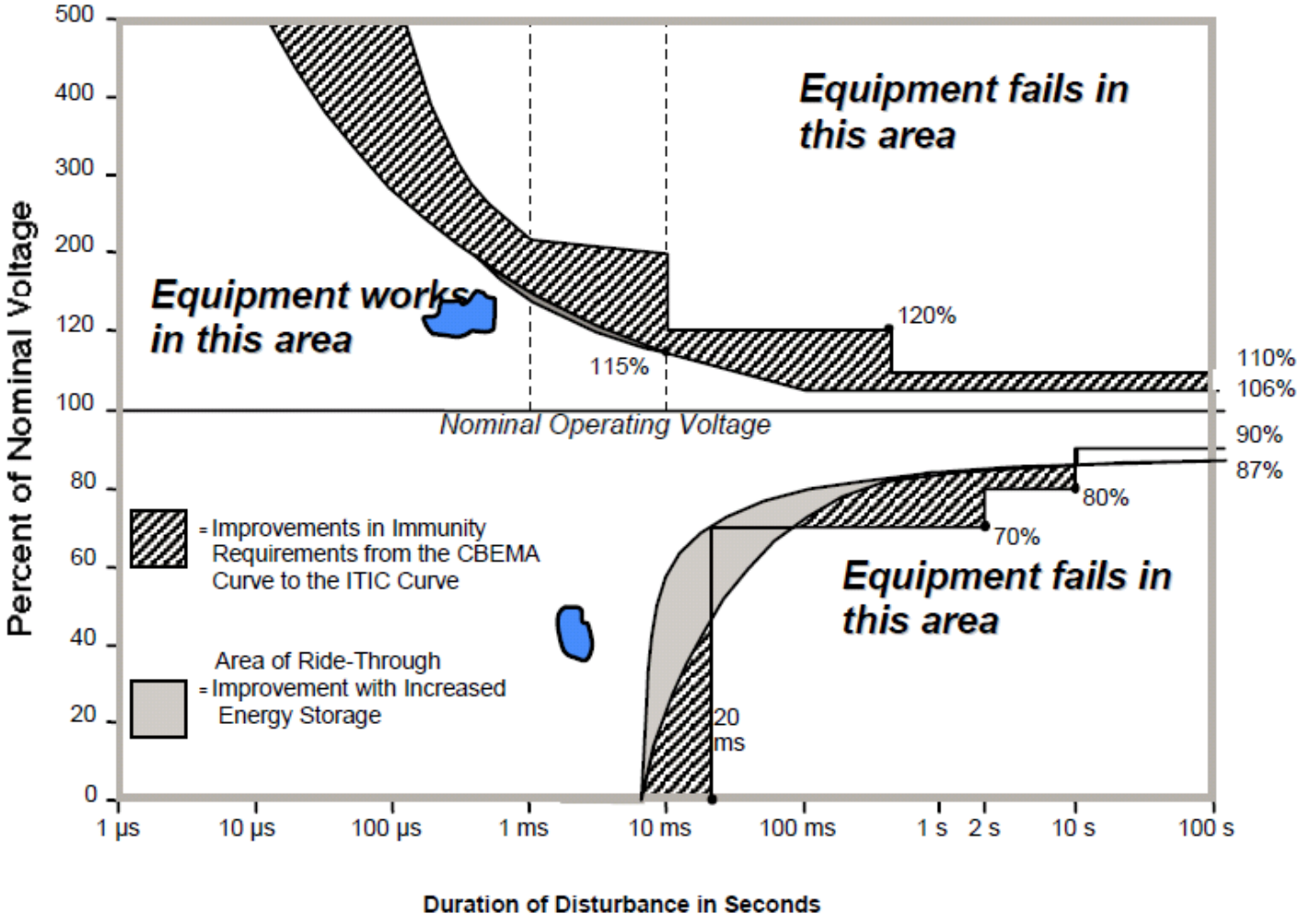
Energy Performance Testing
Test 0: Initial Characterization
Test 1: Nominal Operating Conditions
Test 2: Driver Partial-Load Test
Test 3: Driver No-Load Test
Test 4: Response to Low Steady-State Input Voltage
Test 5: Response to High Steady-State Input Voltage
Test 6: Inrush Current
Test 7: Electrical Performance of a 16-Amp Lighting Circuit
Emissions Testing
Test 8: Input Current Total Harmonic Distortion
Test 9: Line-Conducted Emissions (FCC and CISPR)
Test 10: Radiated Emissions (CISPR only)

SC Test Program for LED Lighting Products

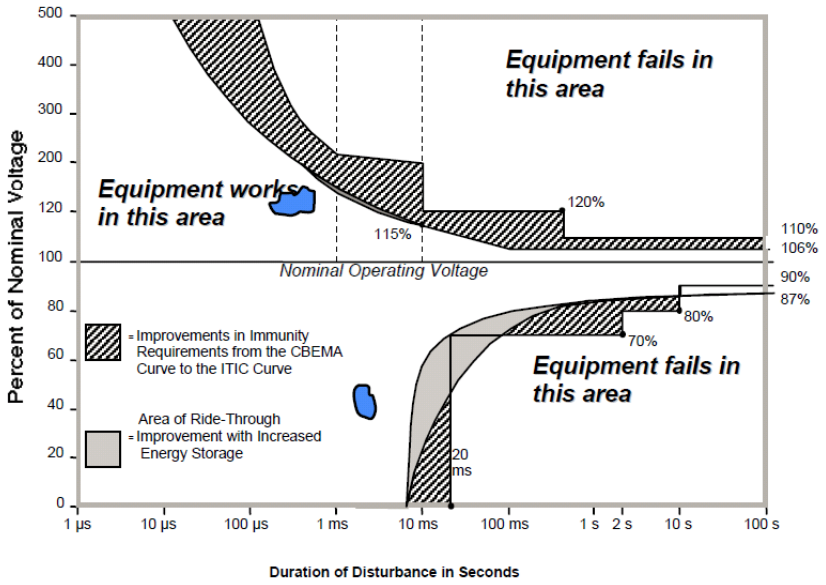
Part 2 – Immunity & Special Tests

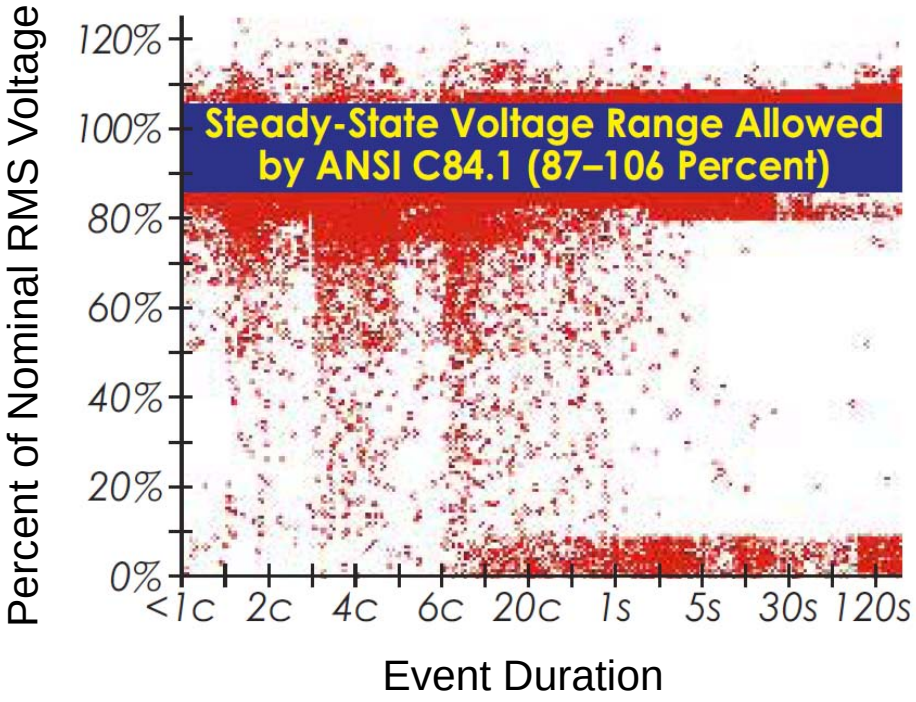
Immunity Testing
Test 11: Susceptibility to Voltage Distortion
Test 12: Susceptibility to Voltage Notching
Test 13: Susceptibility to Voltage Sags
Test 14: Susceptibility to Voltage Swells and Temporary Over Voltages
Test 15: Susceptibility to Voltage Fluctuations (Flicker)
Test 16: 10 x 1000 Voltage Surge Test
Test 17: Electrical Fast Transient (EFT) Burst Test
Test 18: 0.5-µs, 100-kHz Ring Wave Surge Test
Test 19: 1.2/50-µs, 8/20-µs Combination Wave Surge Test
Test 20: 400- to 800-Hz Ring-Wave Surge Test (Capacitor Switching Events)
Test 21: Temporary Overvoltages (TOVs)
Special Tests (Optional)
Test 22: Thermal Performance and Analysis
Test 23: Extended Life Tests
Test 24: Mechanical Vibration Tests
Test 25: Environmental Tests (Humidity)
Test 26: Susceptibility to Neutral-to-Ground Voltage Variations
Test 27: Susceptibility to Ground Impedance Variations and Ground Noise

EPRI is developing *compatibility curves* for LED lighting products



How many electrical disturbances would affect the performance of LED lighting products?





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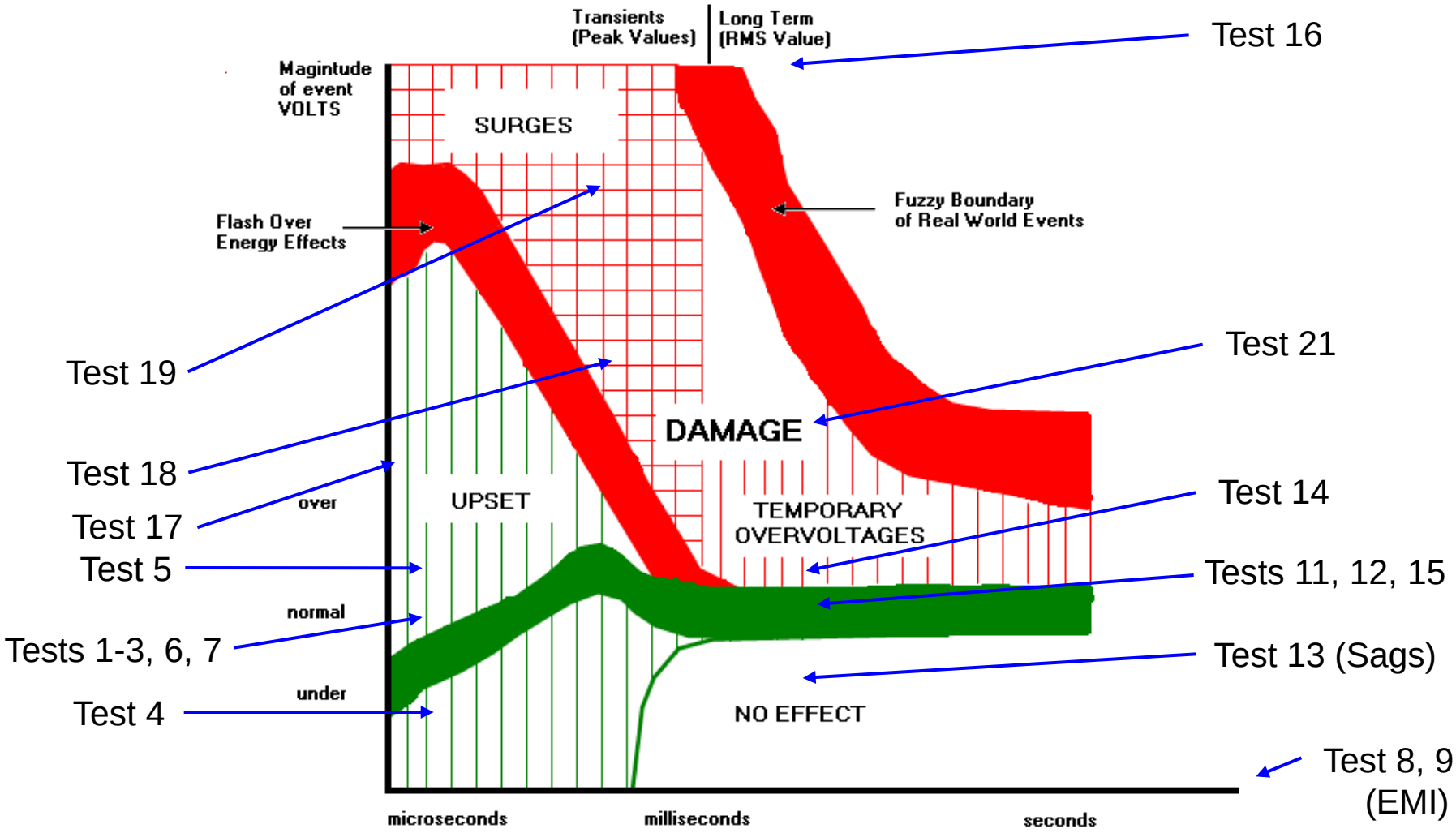
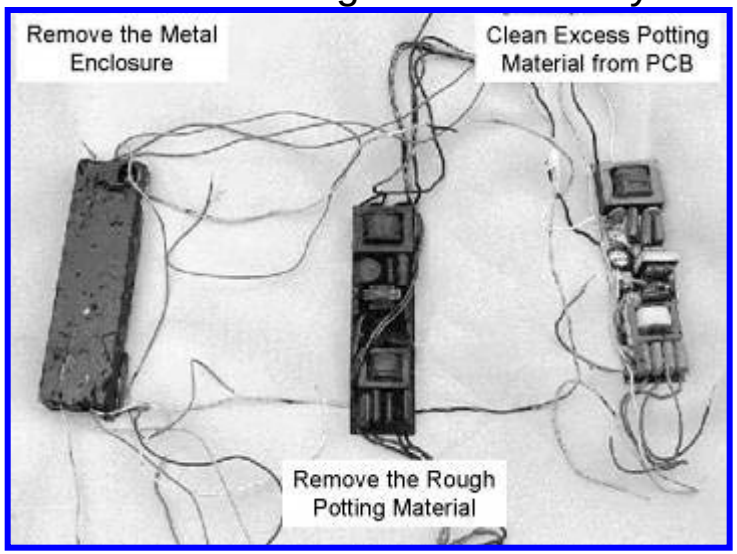
Mapping EPRI System Compatibility Tests to the Voltage Tolerance Envelope



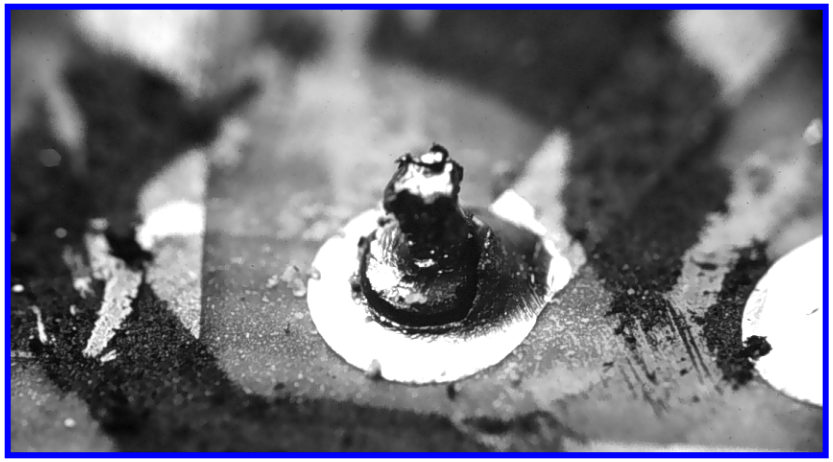
Remember This…

Every Electronic Linear Ballast & CFL Manufacturer & Utility Experienced Financial Losses due to Low Immunity to Electrical Disturbances

Time-Consuming Forensic Analysis

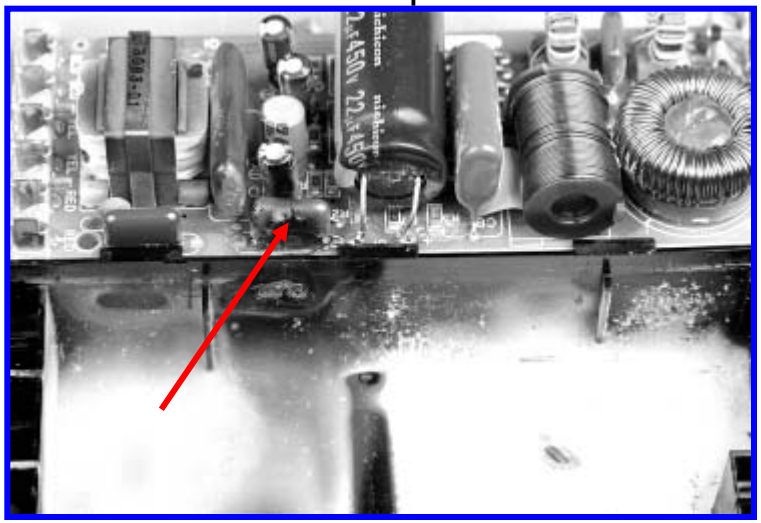


Solder Joint Problems



Failed Components

Failed Components



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Cross-Correlation between Observed Failure & Electrical Disturbance

SSL Product	Observation from Forensic Analyses of Field-Returned SSL Products in EPRI Lighting Lab	Identified Cause of Malfunction or Failure
1	Failed AC line capacitor	Ring-wave surge
2	Blown line fuse	Voltage sag
3	Surface mount resistor failed (catastrophically) in power controller circuit	Over-voltage condition
4	Transistor failed	Transient occurred on driver IC
5	Diode in bridge rectifier failed	Over-voltage condition
6	Metal oxide varistor (MOV) failed catastrophically	Improperly selected MOV & placed in wrong part of circuit
7	Driver control IC failed	Voltage transient
8	DC bus capacitor failed	Over-voltage condition
9	Surface mount diode failed	Over-voltage condition
10	Opto-isolator failed	Combination-wave surge
11	Output filter capacitor failed	Over-voltage condition
12	Power diode failed	Ring-wave surge
13	18 gauge conductor from driver to LED array vaporized	Over-current condition

Driver Failures Can Occur Anywhere on the PCB

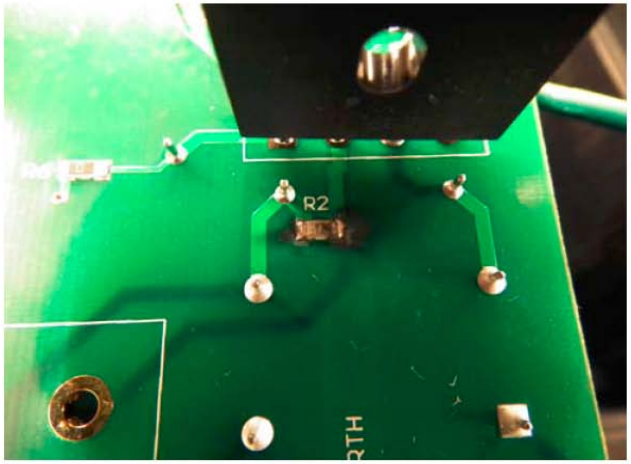


Figure 2. Failure of an SMD resistor (R2) on a circuit board of an SSL product

Figure 3. Failure of an MOV (MOV3) in an SSL product

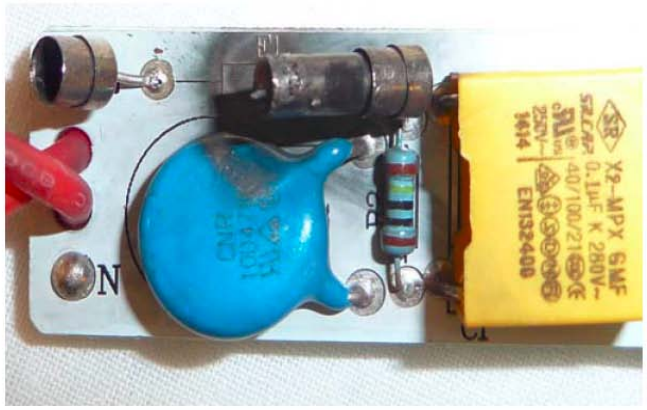


Figure 4. Failure of an AC line fuse

Figure 5. Failure of an AC line fuse that escaped the potting material

Testing: A Critical Part of the Product Design Cycle

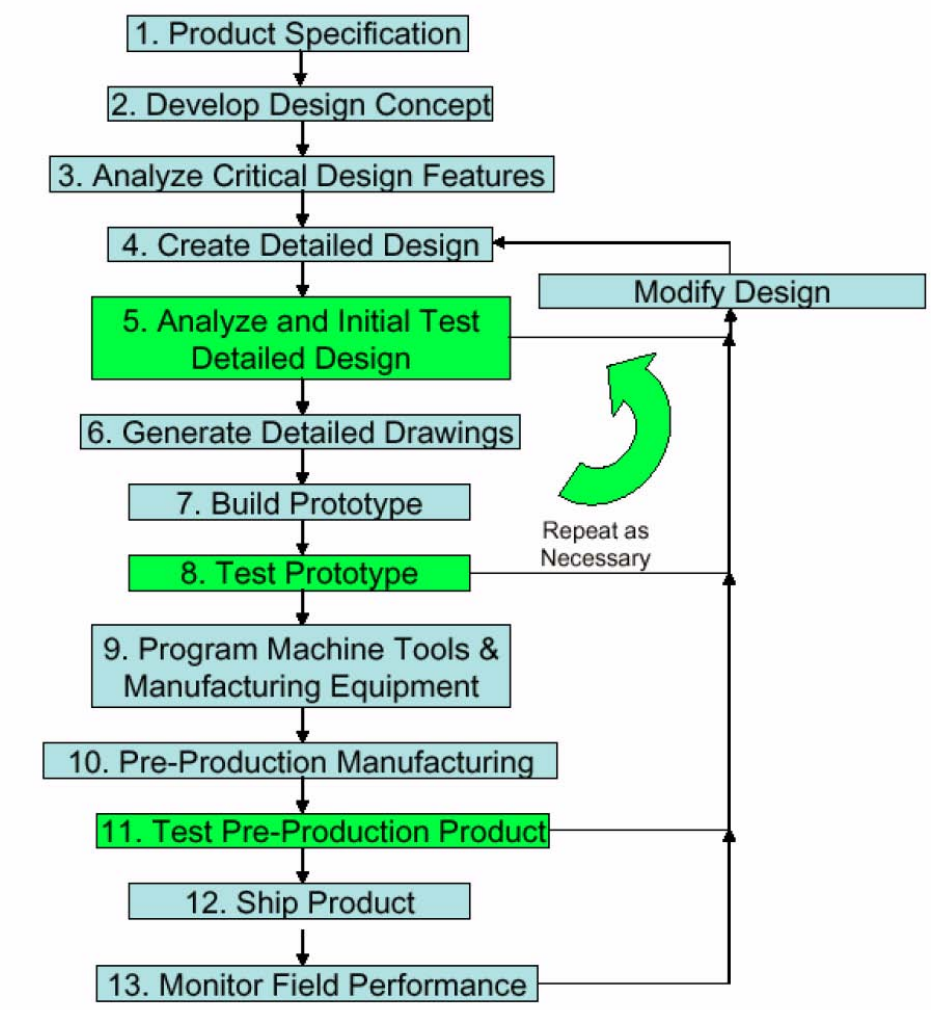
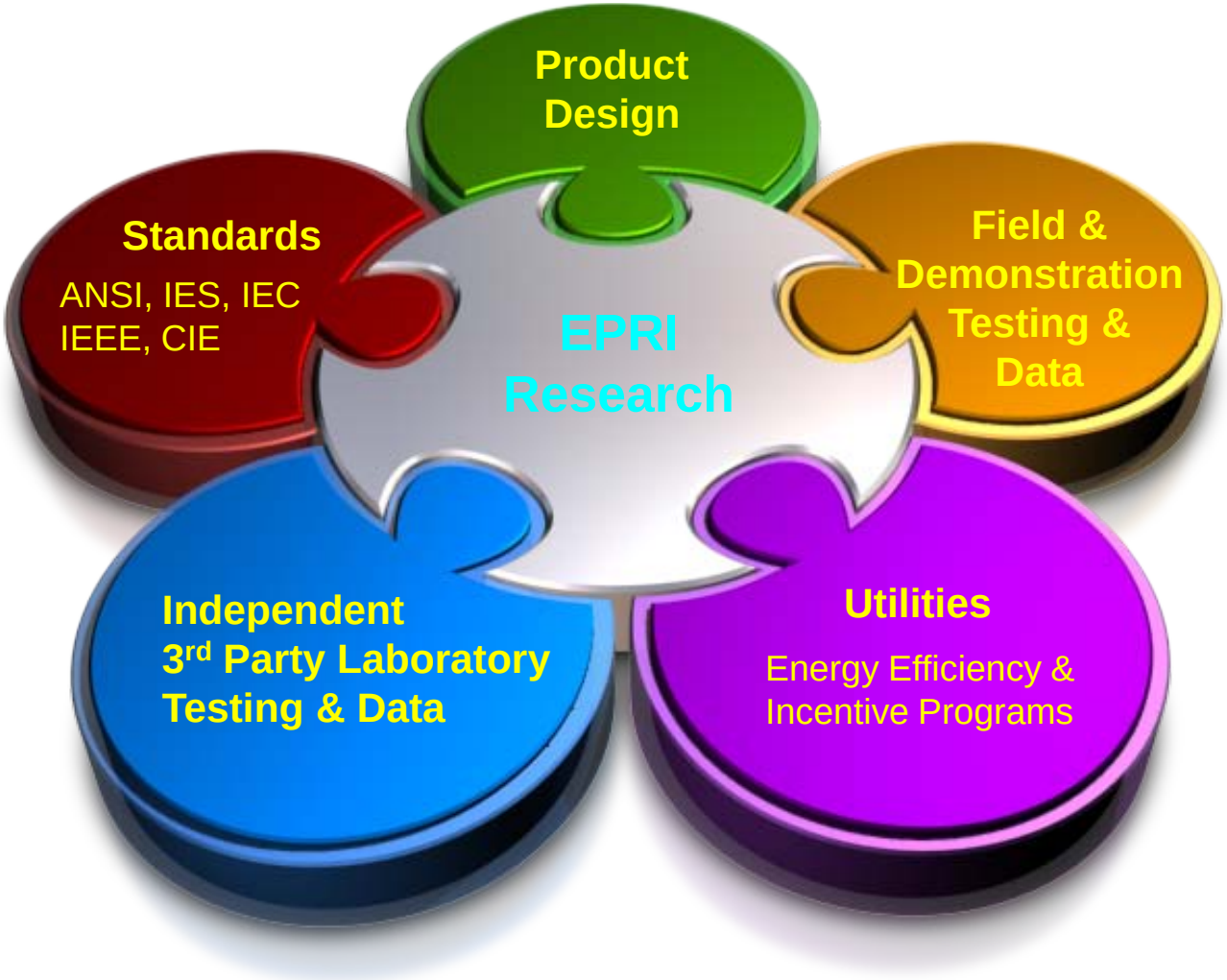


Figure 1-1
The Design Process with Integrated System Compatibility Testing

Connecting the Critical Parts



Contact Information – EPRI Lighting Group

Philip F. Keebler, MSEE
Sr. Researcher – Lighting & EMC
Electric Power Research Institute (EPRI)
Knoxville, Tennessee
865-218-8015
pkeebler@epri.com

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